ELUCIDATION

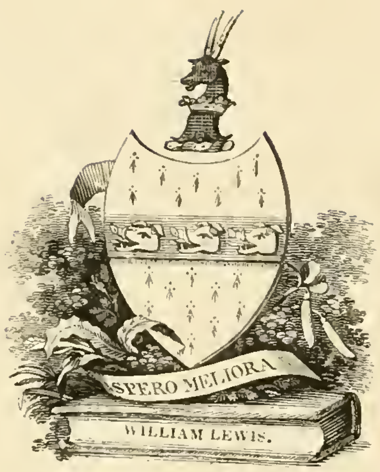
OF

COLOURS,

WITH A

CHROMATOMETER.

by James Sowerby.


SPERO MELIORA
WILLIAM LEWIS.

A NEW ELUCIDATION OF *COLOURS*,

ORIGINAL PRISMATIC, AND MATERIAL;

SHOWING

THEIR CONCORDANCE IN THREE PRIMITIVES,

YELLOW, RED, AND BLUE;

AND

THE MEANS OF PRODUCING, MEASURING, AND MIXING THEM:

WITH

SOME OBSERVATIONS ON THE ACCURACY OF SIR ISAAC NEWTON,

Who——"From the whitening undistinguished blaze
Collecting every ray into its kind,
To the charmed eye educed the gorgeous train
Of Parent Colours."

Thomson.

By JAMES SOWERBY, F.L.S. &c.

Designer of English Botany, and Exotic Botany; Author of English Fungi, British Mineralogy, British Miscellany, the Botanical Drawing Book, &c.—No. 2, Mead Place, Lambeth, Surrey.

London:

Printed by Richard Taylor and Co. Shoe-Lane.

MDCCCIX.

TO THE MEMORY OF

THE GREAT SIR ISAAC NEWTON

I indulge an inclination with much humility to dedicate this gift of Nature, as a part belonging to the foundation of light and colours, first laid by his penetrating genius; presuming that collecting, measuring, and arranging them is a necessary if not an essential appendage. I had dedicated this more naturally, it might be thought, to the Honourable President, Sir Joseph Banks, Bart. and to the Fellows of the Royal Society. The Dedication to the Memory of Sir Isaac Newton being admitted, the latter follows of course, as every thing relating to the philosophical schemes of that great man naturally comes under their cognizance; and they, like his heirs, under such circumstances I hope will be pleased to accept it.

JAMES SOWERBY.

London.

INTRODUCTION.

When I first proposed to publish on Colours, it was merely with an intent of simplifying the means of mixing them, and that chiefly with regard to such as are used for painting in water or oil, with a particular desire to show a means of agreement and ready reference among naturalists and others, as to their identity. This led me to inquire for some permanent and constant means of comparison, from some original source that might always be consulted, and leave no room for doubt. Observing a sort of originality in the prismatic tints of stones, and that I could trace their order, I began with them; but, after all, finding them too fixed as it were for some purposes, and that it would be desirable to mix or unmix the original prismatic tints with the same order as common colours, and perceiving a strange want of agreement in this particular among philosophers, &c., I was the more anxious, especially as to the obtaining the same three primitives as were pretty universally allowed to common colours, viz. Yellow, Red and Blue; for should Nature agree in this, which seemed to me a desideratum, I might then find a means of producing them so as to mix them perfectly, and be able to come to some fair conclusion. I made a few inquiries upon the subject, but to no purpose, as it was generally thought impossible: and having a further desire to measure them, it seemed to be considered as a vanity. I was however satisfied, that as there was something wanted to make the desired agreement, so it might possibly be found out. I therefore determined, if in my power, to find it out; and was much sooner favoured with the discovery than I expected, and that too to a nicety that surprised me much, especially as it was so easy and likely to be brought to perfection, not only to correct former errors, but to serve as a firm basis for future inquiries. Indeed, it may seem a wonder, in the present rapidly improving age, that any thing remained to be done towards the elucidation of colours, either evanescent or natural. I presume, however, that this work in its present form is likely to fill up some important desiderata; and if it is not established as a book of reference, which is much wanted, I hope it will help at least to call one forth, as such a book may be of infinite service in many departments of science, for the subject promises already to branch into many divisions for different purposes. One truth established helps another; and it may give a hint even to the astronomer Dr. Herschel, who has paid so much attention to the subject of prismatic colours, that strong opposites, such as light and dark, may not be proper in the use of telescopes, as when they are next each other, in particular, they may produce the most brilliant prismatic tints by the help of the angle of a lens*. Thus a middle tint I should presume best for lining telescopes. I find a middle tint in my schemes best to neutralize colours (black I believe is in general use for telescopes &c. but I do not know what Dr. Herschel uses).

Again, calculation by means of a prism has been used to assist in examining some of the constellations; if the sun's width at a known distance is such as to show a white space when viewed in a prism, it must be broader or nearer than those constellations that do not show a white space:—thus the smaller objects of our hemisphere show only the four colours of Dr. Wollaston's narrow ray of light, or C. A. Prieur's white thread or silk, which will be understood in the sequel. It is somewhat curious, that the middle tints brought in contact by smallness or narrowness exclude light or white, and be-

* Dr. Herschel probably broke his coloured glasses by some such contrast.

come green, from yellower green to darker and bluer green. May green be reckoned the middle tint in Nature, as grass: it seems suited to our vision. It is not a little remarkable, that many subjects partake of the prismatic order of the colours of the sun or other luminaries, especially hemispherical ones, surrounded in a dark or perhaps aërial medium. Thus the evanescent tints become in effect realized in an admirable manner to our senses, taking due place in Nature to the fullest extent.

I have only hinted at these things, that they may be enlarged upon if it should seem useful. Certainly, some fruits, such as peaches, pears, &c., have, occasionally, nearly if not all the tints allowed to the prism in due order upon them: thus the upper part, or the next under the leaf or stalk, is a full or crimson red, and this is often softened into orange; yellow or yellowish succeeds; then yellowish green; then bluer, till the dull or under side partakes of violet, especially if the warmer rays of an evening sun glow aslant on its downy coat, or help by their reflexion. Artists are generally aware of this in their paintings, and keep the warmer colours above and the coldèr ones below: even the warmer tints in Man, who walks erect and looks on Heaven, are seen most conspicuously in the upper part of his features. Indeed many artists consider the general light and warmer tints with the cold and shady sides (if I may so call them) of the rainbow, as a sort of rule to go by: the lighter side, to blend the colours of the lighter side of the subject, when the softening into the back ground would form a violet; a warm or reddish tint would come next, which would be blended by yellowish orange into the local tint, when the heightening would succeed; next something of the local tint which would begin to recede into the yellowish and shade forming a grayish green; then would succeed a darker shade with a violet tinge, and the rest would depend upon reflexion. Now these tints being judiciously managed, give a richness that is only understood by the artist who practises with such ideas. I have introduced the peach as an example; and I remember, when a young student at the Royal Academy, to have painted from the life with nearly such a lesson from a worthy and most esteemed artist, who was at that time the visiting academician. It would therefore seem that light or shade on convex or concave subjects, or where shadow is, is also accompanied with colours; the smallest shade being compounded not only of light and shade, or black and white, but of many tints depending on the nature of that light; for mere black and white would give an unartist-like manner and coldness, which would be condemned in general, even by the least discerning, although perhaps without knowing why. Light and shade or shades will be shown hereafter to have a greater effect than is usually understood, with regard to colours, and will, I have no doubt, be found useful in many other respects. Light and dark, as a contrast, and for effect, is very ancient, and sufficiently attracted Laban's flocks under the care of Jacob*.

Light is essential in colouring some things and bleaching others; and it was once a valuable secret, that to get the brightest carmine it should in the process of making be dried in the sun. Many chemical substances are changed by exposure to light; oils become whiter. Perhaps even this effect may be assisted with the help of a contrasting shade, that the actions may be more forcibly directed on the object. Light, on an object when seen refracted by the prism, shows its colours; which however do not affect the general local tint of the object which seems to reflect it, but rather depend upon the darks or shadows; and broad flat masses of any coloured object do not appear changed excepting at the extremities, or where dark or shade seems to help to collect the coloured radii: thus it may be possible to make broad tints or narrow ones with such proportions of dark or shade as may be suited for many purposes of the utmost utility in the arts, manufactures, agriculture, &c.

* Genesis xxx. 37 to 41.

That philosophers and artists have long wished for some never-fading colours to fix their ideas and universalize them, is in every age amply verified; and as coloured substances, like all other sublunary things, are liable to a certain decay, so it has been but weakly attempted lately; besides, the difficulty of finding a means of agreement in the modifying and arranging them has been a desideratum, as late works have abundantly showed. Enamel, perhaps, is as durable as any substance, and has with much propriety been proposed: but the uncertainty of an ability to procure an equality throughout a single tint, puts us nearly in the same predicament as with other coloured schemes. This we shall find true in our attempt, as will be too evidently seen in the present examples. We presume our method of arranging will much assist both the colours and the mind, and even this scheme might be desirable in enamel or glass for the sake of durability; but I may question even if the best enameling artists can place colours so well, (which in no way degrades their greater merit,) as it is seldom they have occasion for the experience of an object so trifling to the best of such artists*.

Upon the whole, the necessity of supplying this desideratum need not be dwelt upon, as the numerous attempts to do it are a sufficient acknowledgement, and argue much for its utility. In my researches it has luckily fallen to my lot to find one resource or monitor in Nature, which is as constant as the light from which it is deduced, and the regularity or certainty depends upon very simple materials.

The use of a true original for colours, and a regularity of arrangement, is almost infinite; for to the artist in any line it will be a solid satisfaction to know when he treads on a sure foundation, laid by unerring Nature. The mineralogist, the botanist and the zoologist may in future agree in their descriptions and ideas, so as to identify them to all parts of the world, and the remotest ages.

* Perhaps it may succeed somewhat in transparent oil, but water colours are most convenient for a book.

It was observed to me by a very good friend, "that as the seven tints were permanent, *that* was an evidence of their sufficiency as primitives and their original derivation, and that water was perfect in itself, although it was found to consist of hydrogen and oxygen." The latter was once thought a pure element, and led to wrong conclusions. The former being thought perfect, it will be evident, has also caused wrong conclusions; and as water is not necessary to be formed to produce one of its original parts, hydrogen or oxygen, so, it will be less necessary to mix yellow and red and yellow and blue* to make a yellow! when yellow is originally and necessarily so, to form the very ingredients so unhappily combined, and leading into continued and self-proving errors. Thus water does not form hydrogen and oxygen, but hydrogen and oxygen form water. Yellow, red, and blue, I presume, therefore, will more properly form the remainder of the seven prismatic tints, than either two or more of the seven will form a single primary colour. I would not have insisted so much on this subject, but that the present improving state of natural science seems to demand a concordance of the primitives of prismatic tints and substantial colours, which appear so much to depend on each other; and it has been understood by many, from the time of sir Isaac Newton, that the prismatic tints may be imitated by what I would consider as simple primitives, viz. yellow, red, and blue.

Now to me it seems that, if these are allowed to be the proper primitives of the prismatic tints or colours, there will be a perfect concordance on the most permanent footing.

I should not have set about this work without a confidence of its utility, although I had not intended or expected to carry it quite so far. I therefore may not have arranged it so regularly as I wish,

* It has been, by some, a long mistaken notion, that as yellow is placed between orange and green among the seven tints, it was a natural result from them, when the contrary is so naturally and truly the case, as is proved by the very first hypothesis, seeing that yellow and red make orange, &c.

as every thing did not present itself to me at once, like an old subject, but rather as a new. I therefore hope some allowance will be made by the discerning, more especially in the philosophical part; as the intention is, to generalize the subject: and the author does not pretend to be either a great philosopher or artist; for, if he had been the first, he probably would have wanted enough of the latter to answer the peculiarities of the present intention, and *vice versâ.*

A NEW

ELUCIDATION OF COLOURS,

&c.

There may seem a want of order, in commencing this work with showing rather a finished series than the beginning of one. I have, however, in this instance thought it necessary to give general ideas, and afterwards to begin in as simple a manner as I could; and, by descending to certain particulars, endeavour to lead to a natural result. I therefore show them even the first and the last series of prismatic tints, viz. *light colours* and *dark* ones, as they are in their nature of much consequence, having been very little if at all noticed in natural order, especially the browns and other ternaries. Thus we have, as it were, white as the first beginning of colours, and brown to black the termination of them to our senses. We shall find in the sequel that these include all colours, and that a certain position or arrangement will make them evident, with the most beautiful order and unerring regularity. I am pleased to find these first examples in minerals, whose agency is no less conspicuous in this department, than of the first necessity in most others, showing us much of the nature of light and colours, from the most evanescent* to the more solid or material. They help us much to judge of their permanency, and seem the best vehicles to trace them in, and from their first source; for we may produce them at pleasure,

* Changeable, in many substances, according to the course of the light they are viewed by.

and make our general observations on them at any time. We may press together or open the laminæ which have been partially separated, of gypsum for instance, in order to produce the colours, either concentrically or otherwise, and this may be repeated, or we may allow them to be stationary for future use or practice, and to serve as one of our resources for a natural proof or example, and we may even measure with some accuracy the space allowed in plates for the different tints. (See Dr. Young's excellent paper*.) Thus *Tab.* 1. *a, b, c, d, e, f,* are representations of colours, that are or may be produced in the flaws of or betwixt the laminæ of transparent stones, such as the diamond, gypsum, or selenite, mica, carbonate of lime, &c. (See *Brit. Min. tab.* 2.) I have a specimen of mica showing a minute opening or division of the laminæ of about the eighth of an inch in diameter, having a yellow centre, which I place first; as it succeeds, in the increasing order of density, next to light. It is surrounded by light blue, passing through purplish brown to very dark, when, by degrees, it again passes into faint brown† with a light margin, and then the stone appears to be close and solid surrounding it; *Pl.* 1. *a.* In another part of the same specimen, I have a red centre, to which succeeds the yellow, and the yellow is succeeded by the blue, and the other rings succeed in due order as the first; *Pl.* 1. *b.* A third flaw has blue in the centre, as in *c*, with the red, yellow, and the usual rings in the same succession. It is not often that we can find one colour only shown in these substances, they being more commonly a succession of rings. I have however met with dark brown with a lighter margin, passing to light or white as at *d*, and *e* shows the stone grayish in the centre with the white margin, surrounded by the brown and other rings, as it were reversed in order: it is in fact the curved margin of the various and unequal divisions or fissures in the substance. In general the external or extreme margin finishes with brown, as most of these, whether narrow or broad, do. The other more commonly

* Phil. Trans. 1802.

† Browns have scarcely, if at all, been considered by authors on this subject.

concentrates with yellow, red, or blue, or a mixture depending upon a natural and regular phænomenon: (viz.) That as we have seen in *a*, *b*, *c*, that blue is on the inner side of the dark circle; if there is much proportional breadth, so commonly a white or light space succeeds, passing into yellow, orange, and red; and sometimes the arrangements in succession approach nearer and nearer, and the white is obliterated, and yellow is facing or nearer the light blue: again, the yellow and blue pass into each other in narrow or nearer circles, and produce green very often at the expense of the marginal tints, if I may so call the blue on one hand, and the red on the other. Something like this, or duller and deeper, appears at fig. *g*, and the semicircles surrounding show it more distinctly, although placed here for a no less curious example.

I have perhaps enlarged too much on this subject here. I, however, thought it essential not only to begin with these general premises, but to show some common varieties in the arrangement of prismatic colours, by which we may perceive that there is a perfect rule for proportion in it, however unequal it may at first appear, which seems to me to have been hitherto a desideratum; and as I expect to prove much from the nature of this particular appearance, I have dwelt the longer upon it; which is the more necessary, seeing how orderly sir Isaac Newton produced certain colours by the pressure of two glasses, and how naturally and truly he enumerated them without quite attaining the leading and true cause or principle of that arrangement, which he was so near discovering, and which would undoubtedly have been of the most essential consequence in such good hands. The whole agrees so well with what is said of the experiments of that great man, that, although it is well known, I cannot forbear relating it here. Sir Isaac Newton himself had observed, that as he was compressing two prisms hard together, in order to make their sides (which happened to be a little convex) to touch one another, in the place of contact they were both perfectly transparent, as if they had been but one continued piece of glass. Round the point of contact, where the glasses were a little separated from each other, rings of different colours appeared. To observe more nicely the order of the colours produced in this manner, he took two object-glasses; one of them a plano-convex one belonging to a fourteen-feet refracting telescope, and the other a large double convex one for a telescope of about fifty feet; and laying the former of them upon the latter with its plane side downwards, he pressed them slowly together; by which means the colours very soon emerged, and appeared distinct to a considerable distance. Next to the pellucid central spot, made by the contact of the glasses, succeeded blue, white, yellow and red. The blue was very little in quantity, nor could he discern any violet in it; but the yellow and red were very copious, extending about as far as the white, and four or five times as far as the blue. The next circuit immediately surrounding these consisted of violet, blue, green, yellow and red: all these were copious and vivid, except the green, which was very little in quantity, and seemed more faint and dilute than the other colours: of the other four, the violet or purple was the least in extent, and the blue less than the yellow or red. The third circle of colours was purple, blue, green, yellow, and red: in this the purple seemed more reddish than the violet in the former circle; and the green was more conspicuous, being as brisk and copious as any of the former, except the yellow; but the red began to be a little faded, inclining much to purple. The fourth circle consisted of green and red; and of these the green was very copious, inclining on the one side to blue, and on the other to yellow: but in this fourth circle there was neither blue, violet, nor yellow, and the red was very imperfect and dirty. All the succeeding colours grew more and more imperfect and dilute, till after three or four revolutions they ended in perfect whiteness*. It is perhaps now to be wondered that sir Isaac Newton did not take more particular notice of the fading of the violet and red, or of their becoming more of a diluted cast, and of

* Probably brownish first. I have not the means of trying his glasses, but it seems a general law that has been overlooked, as a sign of obscurity perhaps.

the three primitive tints mixing as the circles became narrower, which was the cause of the green in the third ring. As the colours were found to vary according to different distances of the glass plates from each other, our author showed that they proceeded from the different thicknesses of the plates of air intercepted between the glasses. But to return to the order in which he so naturally found the colours in the circles.—First, the three primitives and the seven prismatic tints naturally mixed from them, which I wish he had been aware of, as it would have accounted for the other rings or revolutions. I have therefore produced an example of the order of his tints in *Plate* 1. *figures* 1, 2, 3, &c. in which it will appear that the rings which are called revolutions begin in a natural order, although reverse to what I have begun with, viz. first blue, whereas I have begun with yellow. This however is because his instruments were reversed, two opposite convex surfaces producing them in his scheme, and two concave opposites producing my past example.

Thus, No. 1 is Blue
2 — White*
3 — Yellow
4 — Red
5 — Violet
6 — Blue
7 — Green
8 — Yellow
9 — Red
10 — Purple
11 — Blue
12 — Green
13 — Yellow
14 — Red
15 — Greenish
16 — Dirtyish Red, &c.

* White is light, dependent upon the distance of the rings or revolutions which begin or end the series, as Red or Blue, which in these cases come back to back as it were.

Blue, yellow, and red, omitting white as neuter, we find, are his three first colours; and in the next range, we only want indigo to begin or terminate the series after the red and orange, between the yellow and red, to complete the seven prismatic tints in the second series; which, if we observe the joining of the red and blue by being viewed at a certain distance, will seem very nearly to be the real case: indeed, a proper softening of one into the other would make it too nice for our discernment; although, if the red is pure, it ought to be only violet, which in a bad light will appear as dull as common indigo, as a deep purple is dulled by the yellower rays of candle-light and lilac, and all purples appear brightest by day-light. The approach or nearer appearance of the two revolutions will also in this instance be found to form green, where the white took place before, as the yellow and blue join to form it; and so it is with the other rings or revolutions which approach nearer and nearer, next losing the yellow as it were by mixing, and are both duller and paler from want of that opposition to stronger light or darkness, which probably towards the end became obscure, finishing in perfect whiteness, or light reflected on the face of the glass. The middle tint, if I may so call it, at *g*, would not allow of a dark blue margin, as will be understood more perfectly hereafter.

Having therefore produced the order of his tints, which without more instruction than his words we are enabled to do very perfectly, and as the tints come according to Nature, so we may conclude he was right, as may always be proved by the order of the colours; for the prismatic tints, however irregular they may appear, or seem confounded, are most perfectly and unerringly regular in their order: thus the rainbow, the colours in the flaws of stones, &c. follow the same rule, even to the coal called peacock coal, for the colours of which, see *British Mineralogy, tab.* 49. Thus if we look through the prism, at a window or a multitude of objects, or any varied number even of coloured things*, all will be found to be reducible to certain

* A print, with many objects, coloured or uncoloured, may be convenient to examine.

rules, as a given proportion of light or shade produces proportionate colours with as much certainty as any figure in arithmetic.

It may perhaps be convenient in this place to ask, whether it is the laminæ which cause the plates of air of a certain dimension to reflect a particular tint or colour, or whether, like the rainbow, parhelion, or halo, it may not be produced by the crystallized particles of the substance acting as water, ice, or hail* ?

Iris-like tints are to be produced many ways, and sometimes with very remarkable phænomena. At Weather-Cot Cave, in Yorkshire, it is said that if, at certain seasons, a person placed at the mouth of the cave look at the stream or fall of water that is precipitated from above it, he will see six or more iris-like appearances. These are probably governed by the shadow of the prominences of the rock, or perhaps the disturbed undulations of the water: either repetition seems to depend upon something analogous to the effect of dark lines, which will be seen in the present theory, and the same with the repetitions in different substances, and when artifically contrived by convex or plane glasses, &c. or perhaps in this latter it may depend upon the grinding of the glass, which, however finely polished and perfectly smooth to our perception, is nevertheless full of the irregularities left by the tool of the workman in turning it to grind or polish it ; and this would greatly agree with the idea of the crystalline particles producing the colours in various minerals ; and it may seem that a double combination of the watery particles, or mist and shadow, produced the circles around the shadows of the heads of sir Joseph Banks and his companions, in the bason of the boiling fountain of Geyer, when visiting Iceland in 1771, as Von

* As it seems somewhat doubted, what is the form of ice in its crystallization, we can assure our readers that we have found snow in regular tetraëdrons, *Brit. Min. tab.* 281, and in hexaëdral pyramids, produced by truncation at the edges of the tetraëdrons; sometimes truncated at the top; in hexaëdral columns formed of plates curiously stellated with spiculæ; and hail in regular tetraëdrons, somewhat plated with nuclei: I have also found the tetraëdron with rounded faces, somewhat like the sulphate of copper, *British Mineralogy, tab.* 77, but nearer round, like a drop of water.

Troil says, that each saw around the shadow of his own head, though not around the shadows of the heads of others, a circle of almost the same colours which compose the rainbow, and around this another circle. There are many curious instances of such phænomena. I have known boys to imitate the rainbow by simply spirting water from their mouths, in the sunshine, &c. to imitate fine rain, producing the rainbow tints extremely well.

Something like this may account for the number of circles or segments of circles in the various substances in which they happened to form, even the common air. Thus we may conceive certain undulations, not unaptly represented in the common crown glass of our windows (which it appears is made by taking a largish ball of metal* and spreading it by turning the instrument as when a mop is whirled or trundled to dry it), when the arrangement of the particles of water in the air, like the rings in the glass, varying, gives each a similar effect, or forms circles Now it will be found that the eye cannot see those circles, but by the proportion of light and shadow with the reflexions: and betwixt every swelling, or other cause of light and shadow, there always appear the coloured rings when looked at in the sun, or when the sun shines upon the plate so formed, or obliquely through it on a wall, &c. The eye is often so circumstanced, that things not at all forming real circles have yet the coloured appearance of them, as a shining waxed table, a greasy appearance on glass, or the almost imperceptible dust that may be on some smooth surfaces, the most minute particles of damp, breathing on glass and copper, or the slime of snails, and many other objects sufficiently well known, either requiring the prism to refract the tints, or forming them to the unassisted eye. These colours frequently obtain permanency, and we may trace them till they seem to approach solidity in heated or oxidized steel or other metals, which begin with yellow: this is followed by orange, then the red, passing to crimson or violet, and thence to blue, as the heat is con-

* In the glass furnace, the melted glass is called metal by the workmen.

tinued; and if it is still heated, fresh sets of colours are formed; which is not only a proof of a sort of permanence of colours brought on by heat, but of their regularity in successively forming rings, which is rather universal where colours are formed, especially as they depend upon some sort of prismatic agency: but the yellow and red are not very bright, as the steel does not reflect them so well as many other substances, although the blue is generally beautifully reflected. Nature, however, produces them all most brilliantly on some iron ores and other oxides.

Having gone thus far, I found it might give much satisfaction if I were to examine the light from the full sun's rays, as an original source, in the open air. I therefore took the usual three-sided prism, and was highly gratified by observing white in the refracted reflexion of the sun, as seen of an oval form, light on the face of the prism, and the three primitive tints, a fine yellow, a rich red, and a light blue: (see *Tab.* 2. *fig.* 1 and 2,) and I found, by turning the prism, very beautiful phænomena took place within it, scarcely, if at all, before noticed in open light. The rays, as they become more oblique, spread over each other, the yellow over the white to the blue forms green, while the blue on the darker side is changed into violet and indigo. The red, by the same motion, passes over some of the yellow spreading into orange, and thus are formed the regular seven prismatic tints or spectrum. At the same time as the above, may be seen refracted immediately from the sun's most brilliant rays, upon any object within a few inches, a fine image of the prism bordered lengthwise, by the same three tints: (see *Tab.* 2, *fig.* 3.) This shows the primitive tints on a larger scale, and will therefore give a fuller explanation of the whole. Thus the middle I call white, as the more direct light, the yellow is below it, the red lowest, and the blue on the uppermost or opposite side, blending but a little with each other, and least so when most vivid, or when the oval reflexion, *fig.* 2, is nearest in form to a circle. When a strip of white paper is seen through a prism, at a proper distance, on a mahogany or dark table, blue will terminate one edge, and red another, with the same appearance as the above; and the proper motion of the prism or paper will produce the green, orange, indigo, and violet, if the paper is not too broad. We therefore find three original primitive tints may be formed distinctly on white paper *.

Rich lights, or whites, and full or more perfect darkness opposing each other, produce the more brilliant tints. The rich light of the sun dispelling the darkness of the morning, or passing away in the evening, produces more apparent colour than at noon when the whole atmosphere is illuminated; and a small candle in a large room, surrounded as it were by much darkness, gives as great brilliancy in the prism as the sun itself: and again, the prismatic rays collected from the sun require a quantity of shade to show them most brilliantly:—thus they were generally refracted into a dark room. Next to this we might consider convexity and concavity; and it will be found that they add to the brilliancy, as they allow a greater strength of light and shade. Convexity and concavity amount, by undulation, as it were, to nearly the same thing as light and shade (by which artists have their imitative power); and any light with shade will produce prismatic tints; thus, as it were, reducing the production of tints to light and shade, or white and black. We shall find the means of illustrating this in every necessary example. Hence it is found, that as the appearance of colour depends upon a certain opposition of light and darkness, so much depends upon the proportion of each for the colour they may produce, and the degree or strength of it. I therefore look at the middle of a piece of dense smooth black paper with the prism, and perceive no colour; if I produce a small dot, or ray of light, or streak of white, immediately certain prismatic tints are produced, according to the proportion, from

* Dr. Wollaston, however, as an original in philosophy, examined a narrow ray of light, and found what he considered as the four primitives; and Dr. Young, a broader ray, by which he determines seven primitives, including white. I think it will be seen that the breadth of the ray will naturally vary the appearance, as in a broad ray, or a ray of a certain proportion, they ellow and blue do not mix as in a narrow one, unless by turning the prism.

three to seven, like those of a rainbow *. As I admit more light, or make the marks broader and larger, the colours become brighter and more separated, till white is admitted in the broadest, when it will appear that the white, with yellow, red and blue, only remain, and perhaps a little mixture, between the bright red and yellow, of orange †, and the yellow with the light or white, naturally blend into each other, and the blue is also softened into the white terminating at the lower edge. Having thus produced the coloured rays by a little light and much black, it may be proper to try a contrary process, by a little black and much white. We should therefore look at the middle of a piece of white paper, or any white object, when if smooth, and free from spots or marks, we shall perceive no colour; but if a fine stroke of black be produced, pale tints or colours will be seen; but if more black is added, the colours will be more distinct in a certain proportion. The order of the colours will commence as it were with the penumbra of the former experiment on light, as light blue above passing downwards into indigo and violet, the white immediately beneath partaking of the red and yellow, as in the upper part of the white line, and the blue will not recommence till something terminates the space of white, as a wrinkle or shadow; the margin of the paper or book, a stroke with a pen, &c. producing, (and we have power of continuing) the same phænomena at pleasure. It was just observed, that if we added more black the colours would be more distinct in a certain proportion; I may add, that they will be more vivid and apparently more perfect.

Ultimate perfection not being in the power of mortals, it is well if we are allowed to attain to a certain degree of it; and it is surely a high satisfaction to arrive at any certainty within our limited sphere. If proportion therefore of black will naturally or artificially discover the quality or quantity of the coloured rays, finding this

* The rainbow mostly shows the same set of tints more or less brilliant.

† The three tints or colours may be made to mix and even to form browns, by turning the prism on its axis so much as to show a lengthened range of colours.

proportion constant we become capable of a certain accuracy: we are furthermore led to reduce them to any proportion at pleasure, as we can repeatedly produce them: (see *Tab.* 3. and 4.)

Seeing them produced in any place at pleasure, it will be found that they may be brought or placed in contact with each other, and be mixed: (see *Tab.* 4. *d. e.* &c.) Thus we are enabled to show, with as much nicety and calculation as we think proper, what may be the primitive rays; and considering them as reduced to three, we can produce by means of a few strokes properly placed any possible tint, naturally and truly, without equivocation. In the present instance, for simplicity' sake, I determine the proportion by the breadth of the black. Thus a given tint may be represented by a given proportion of black upon white, as in *fig. d.* &c. We have therefore a very simple means of operation for accomplishing what has long been thought beyond our reach.

It appears that the primaries chiefly depend on the edges of the white and black of a certain proportion in contact, and that orange and green depend on the narrowness of the white between two black edges: thus a broad light upon black effuses yellow, red and blue, the red and blue always bordering more or less on the black back ground, and the yellow appearing upon some part of the space of light or white, whatever light it is, even the shining or gloss light on any black or dark coloured surface; and should the light be narrow, the blue on one side and the red on the other mix with the yellow, independent of the motion of the prism *; and that the light being still narrower, the yellow is lost in green formed by its mixing with the blue; and when the red reaches the blue

* I do not put a black page with white streaks as an example of this; those who have a mind to examine it with a prism may easily procure such. The light spaces in *Tab.* 3. *f. e. d.* answer nearly the same purpose, showing the space of the lights producing the tints, which are put on the side for better explanation: the lights being left in these examples may be made use of, and will show the colours nearly as figured in the proper places for comparison. As we intend to use a white ground as most convenient, the proportion of black producing the tints will chiefly be considered.

side, it becomes purple, soon after which they may be lost in the narrowness of the line. Thus a single light space may be contrived to show with the prism white, yellow, red and blue ; and by mixture, orange, green and purple. So that we have primaries and binary compounds, but no ternary compounds or browns *.

Nature having dictated thus much, I presumed to look further, and found that there wanted nothing to form browns, except the means of bringing the proper proportion of colours together, something like the mixing of material colours. It was therefore required to contrive that the yellow, red and blue rays should pass among each other, for the production of browns or ternaries. I succeeded in accomplishing this, as shall be shown presently.

Finding that artificial light and dark will, by means of the prism, in common daylight, give all the original tints, it was thought necessary to show that yellow, red and blue, artificially contrived or placed, produce the three or more tints, and the tints so produced partake of the colour of the yellow, red, or blue, that produce them: (see *Tab.* 3. *a. b. c.*) in which are instanced, first, the yellow, *a.* The white space between the two yellows would produce 0 a proportion of white, 1 a proportion of yellow, 2 a proportion of red, and 3 a proportion of blue. The yellow is pretty good, being produced by the prism from yellow. The red being produced by the yellow partakes of it, and forms an orange tint. The blue is pale and wants brilliancy, on account of the yellow being the palest of colours, therefore a bad substitute for black. The penumbra below the blue has a poor reddish tint, partaking of the yellow, where violet would take place if produced by black, and so of the rest. *b.* The two reds will be seen to give an effect to the prismatic tints evidently depending upon the red that produces them, and so of the blue. It is however remarkable that the red *c.* 2 is more orange than when produced by black, the seven prismatic tints beneath which having among them more perfect yellow, red and blue. Thus, black or dark in this

* The motion of the prism, however, is to be left out of the question at present.

case seems to have the power of producing these tints in a sort of neutral manner, as if it only relieved them in their utmost purity; (*Tab.* 3. *g. h. i.*) and thin or pale tints marked by dark, or black, still give pale colours in proportion as they are pallid or less forcible themselves.

COLOURS PRODUCED BY A CERTAIN BREADTH OF LIGHT ADMITTED BETWEEN REGULAR PROPORTIONS OF BLACK,

At 5 or 6 Inches Distance from the Prism.

Tab. 3. *f.* is a proportion that may give a general idea of four colours, red, blue, green and indigo; the yellow being just seen at the edge of the green. In many instances the dazzling richness of the tints gives them more distinctness than perhaps belongs to them, (see Dr. Wollaston, and Dr. Young's descriptions, with that of Prieur's,) but I believe the tints in all cases blend a little as in our figures, but " who can paint as Nature paints" must argue for the want of nicety in them. *Tab.* 4. *e.* will perhaps convey a tolerable hint of the wider proportion producing the usual idea of the seven prismatic tints of sir Isaac Newton, and show how they mix:

No. 2. Red	No. 4. Orange	Red and Yellow.
No. 1. Yellow	No. 5. Green	Yellow and Blue.
	No. 6. Indigo	Blue and a little Red.
No. 3. Blue	No. 7. Violet	Blue and Red.

It is perhaps difficult to account for the rays that produce the two last mixtures. We, however, always see them more or less perfectly. I suspect that the penumbra or loose rays that always accompany a beam of light, produce again by refraction the red, yellow, and blue, in a fainter manner upon the dark ground outside the principal spectrum. Thus the indigo No. 6. is found to consist of the blue with a proportion of the pale edge of the red so produced, and the violet No. 7. has a portion of the stronger red in addition to the blue. *Tab.* 3. *g. h. i.* show that a narrow line of black gives the appearance of three tints chiefly, and those pale, as it were diluted with white, or water, as it has been done by the artist in the example; and it is a general rule of Nature, in diluting colours, to give them a bluer cast to our senses, whether in prismatic or material colours, as we shall find upon a fair trial. The broader line *h.* is less pale, and has four colours more distinct, blending into each other a little: *i.* shows five tints distinctly and vividly, although somewhat blended.

Thus *g* has	Yellow Red Blue.
—— *h* —	Yellow Red Violet Blue.
—— *i* —	Yellow Red Violet Indigo Blue.

The gradual blending or passage from one to another is generally too indistinct for use, excepting on some occasions. The yellow and blue, that give a broader appearance in colours than the black producing them, have a share or partake of the white, as it must be remembered that they depend on both. Thus it produces by means of the light on one side two proportions of yellow, and on the other one of blue. I have before shown that a given proportion of light or dark produces a given quantity or force of tint or colour. In the present scheme, in which the mixing is to be more perfectly understood, I have endeavoured to place the black marks in such a position, that it may be seen what tints become mixed with others by leaving a portion of each unmixed. The upper five figures, *Tab.* 4. *c.* show the quantity of black that produces those colours represented in the lower five figures *Tab.* 4. *d. c.* 1 *, therefore, by the

* It was thought convenient, to prevent confusion in examining the subject with the

help of a prism, will appear like *d.* 1, having the five prismatic tints, as *Tab.* 3. *i*; *d.* 1 being distant like *c.* 1 from *c.* 2, it does not interfere with *d.* 2, but *c.* 2 is so near *c.* 3, as to allow one portion of yellow, as in *d.* 2, which does not diminish in breadth, to reach the blue of *c.* 3, forming a green binary, that may be distinctly seen, without mixing with the other colours; and so of the rest, which by their construction give deeper mixtures of greens; and finally they become triple compounds, as may be seen at *c.* 4 and 5, the red of 4 being mixed with the blue of 5, the yellow of which passes as it were over the violet and purplish red of 5, causing blue, red, or yellow browns, in many degrees, where it passes over the red, the browns becoming warmer, &c. No. 5 is narrow, like *Tab.* 3. *g.* that it may as it were admit of the colours produced from the black of 4 above it being effective. Thus we have a means of producing browns, and different proportions may be made use of for different purposes of measure, &c., as these are portioned in divisions of about the 10th of an inch in width, to show what is the proportion mixed or causing the mixture. Thus the four examples of black, each about $\frac{4}{10}$ths of an inch wide, approach nearer by $\frac{1}{10}$th, each producing, in conjunction with its proportion of white, a broad set of colours, and this is made distinct even in the narrow line, 5, which is only $\frac{3}{40}$ths of an inch wide, and $\frac{1}{40}$th is left of white, (see *c.* 4 and 5, and *d.* 4 and 5,) which just allows of an almost imperceptible penumbra to join the brown in the latter example.

OF GRADUATING TINTS, &c. BY WEDGES.

If two wedges are placed opposite each other, they may be so arranged that the space between shall allow the colours produced to form a green mixture, and the green thus formed will be blue green

prism, to put as few figures of reference as possible, as in such examination each figure will give a certain quantity of colour. We therefore request the reader will understand that *c.* 1 means the black mark nearest the letter *c*; and *d.* 1 the first range of colours nearest *d*, reckoning downwards *c.* or *d.* 1, 2, 3, 4, 5.

at one end and yellow green at the other end, at the same time it will be very gradual, and so of the other tints, but there will be no browns: see *Tab.* 4. *e.*

The outline *f.* with the squares will show how any spot may be measured by length and breadth, as well as show the usual division of parts that constitute the best proportions for the most perfect colours.

Some apology may here be necessary, on account of the difficulty of colouring the examples. It however may be urged, as in all other cases, that the most perfect artist, or the most perfect materials we borrow from Nature, resemble every thing else borrowed from that source, and we must refer to the Great Original alone for perfection. The use of the prism therefore is advisable to all that can have an opportunity to procure one; and when I have shown a means of forming a long wedge as most appropriate for seeing a large variety (see *Tab.* 7.) I shall proceed to explain it: and I may here observe, that it will be a fund of amusement to practise the producing of tints by these means, when perhaps something will be found out to improve and make it more instructive: An apparatus for thus measuring tints, or colours, I have called a Chromatometer.

Having thus far spoken chiefly of prismatic colours, it may not be amiss to show the effect of mixing material colours which correspond exactly.

Primary tints or colours I have considered as yellow, red and blue, because I do not comprehend that there has been proposed any way of compounding them from others, that I am not perfectly sure is founded on some deception; and finding that they are capable of producing all others by mixture, in every method I have had opportunity of examining with the greatest certainty. Venturing this consideration as conclusive, as well from the opinion of many that I consider competent judges, as my own, I proceed to say something of the mixing them in two's or

Binaries. Tab. 4. *a.* Now yellow No. 1 passing among red No. 2, forms distinctly, when viewed at a moderate distance or from the bottom of the plate, the orange binary; and again, yellow No. 1 passing among blue No 3, forms the green binary; and lastly, red No. 2, at the bottom of letter *a.* passing among blue No. 3, forms the violet or purple binary: the whole sum of the proper binaries, excepting their being lighter or darker.

I shall now consider them combined by threes, or in *Ternaries*, *b.* at the bottom of the same *Tab.* 4. thus; Nos. 1 and 3, yellow and blue, pass into Nos. 2 and 3, red and blue, and the yellow and red being most prominent, the effect becomes at a moderate distance, or from the top of the plate, orange brown, as at the bottom half; and where there is a double portion of blue as in the upper half, it is a darker brown when seen at such a distance as that the effect may unite the whole to our vision. We see therefore that independent coloured rays may become so placed as to give the sense of a perfect mixture, which would have been the case with these if the lines had not been made visible, which, however, was absolutely necessary to explain them to our purpose: fine dots of the primaries among each other would produce binaries or ternaries with a similar effect, also one transparent tint over another, &c.

CHROMATOMETER.

I now enter upon a curious subject; and I presume that even after what has been said and done, it will appear at first a sort of chimæra for a parcel of dark unintelligible forms to give a most exact account of the proportion of colours. Having in the preceding part shown in what manner colours are produced by means of the proportions of black upon a white ground, or white on a black ground, this is intended to serve as a lasting means of proving the hypothesis, or as a test for any particular tint, under whatever impression we wish to form a comparison.

I shall here denominate the black forms productors, as they appear to produce the colours; their proportions being *told* or measured to identify them when examined with the prism at a certain distance; but this varies with the refractive power of the prism, wherefore some index is necessary to determine it.

I considered that, as perfect red is equal in breadth to the 4th part of its own productor, and is equal to the pale blue above any productor, so an increase of width at one end of the wedge, of one fourth part, will be equal to the width of the perfectest red or pale blue to be expected from it, and it will be a regulator or index for the whole of the instrument.

Thus when the person has the prism so placed, that the upper edge of the light blue, above the first wedge, is in a right line from the edge of this index, or the dark blue upon it, I expect a similar breadth of scarlet will be at the bottom, adjoining an equal breadth of red under the index, supposing the index formed at the top, for it may be either at the top or bottom, but I prefer the top as being least in the way, (see the left hand end of the upper figure, *Tab.* 7.) This wedge, at the beginning including the index, contains five divisions which is equal to a much broader black space, for perfect red is given where it is four parts, and no greater width will give so perfect a red, but will always give scarlet. It will be seen that this proportion is observed in the examples of *Tab.* 3. and 4. In a chromatometer it should not be forgotten, that as few lines as possible should come in the way, and that at any rate extra horizontal lines, from the construction which at present seems best, will be greatly in the way, and even perpendicular ones will be a little so if not drawn quite through the scheme; but to avoid both, I have managed that the productors in the lower figure shall so correspond with a certain measure that it may be immediately understood. But to proceed with a sketch of the upper wedge. As an inch and $\frac{1}{4}$th produces scarlet, when viewed at a foot or more, one inch produces red, and $\frac{4}{5}$ths produce lighter red approaching crimson: thus we may pass from the upper portion of the wedge to the next, beginning immediately where the above left off, and consequently with the same tint, (which may be noted as a proof of the proper position of the prism it is viewed by,) this will become more and more dilute to the end. The third part of the wedge begins where the second left off, with the same proportion and colour, and so of the other two; as these diminish, the red diminishes, or becomes more and more dilute, till lost at the end of the fifth or last line of the wedge. The red, in the way I generally look at the prism, is at the bottom of these productors, as I may perhaps call them; at the same time the blue at the top will diminish from full and perfect blue to the most dilute immediately opposite to the reds, and the yellow will do the same under the red, but is double the breadth, as represented in *Tab.* 4. This wedge therefore produces an infinite variety of these three primitive tints, from the most full and perfect to the most dilute, which may be measured precisely at pleasure in a very certain manner; so that every person may, in a common light, agree in pointing out a precise tint, even at distant parts of the world, if a similar wedge or chromatometer is used. Thus suppose the present to be a foundation, and for sake of accuracy was in general use, I would say, the red of *Euphorbia Peplis* for instance, (see English Botany, *Tab.* 2002.) is, or should be, equal to one inch, that is equal to the red given by such a width of black on white paper; and so of any tint or colour of any subject; and thus we may make conclusive comparisons, and learn what was intended, though time had caused it to fade.

CHROMATOMETER CONSIDERED SOMEWHAT ABSTRACTEDLY.

Hitherto it has been chiefly shown how the prism may be used to produce colours in a book. It may now be necessary to show the use of the Chromatometer as an independent instrument (something like a barometer), as a useful and if we please an ornamental appendage in a parlour or study, with a more exact method of applying it.

It might therefore be flattened on a board and hung like a picture, decorated with a gold or other frame that does not overshadow it, perhaps rather in the shady corner of a room to preserve it, and when used, so placed that it may be nearly perpendicular so that the beams of light in the room, may illuminate the face of it; when a prism may be adjusted at a proper distance opposite to it. The prism may also have been selected, and perhaps measured as to its power of refraction, from which there may be a means of determining the distance or angle to be subtended, &c., in which case it will be most competent for use.

One angle of the prism should be directed towards it, and the spectator should look in at the opposite face of the prism towards the lower face, where the spectrum will appear in great beauty and order.

The upper separated wedge should be looked at by itself, and the lower one also. By use we may afterwards readily compare them, by moving the prism.

The wedge or open chromatometer, *Tab. 7. upper fig.* The square at the beginning will indicate the proper distance, by giving the spectator eight divisions or tints of regular and equal proportions, viz.

1 Light Blue	apparently above the black space.
2 Darker Blue 3 Violet 4 Blue Black 5 Black 6 Scarlet	upon the black space.
7 Yellow 8 Lighter Yellow	below the black space.

A broader square will not give more divisions of colours either regular or otherwise, if observed either at the same or at a less distance.

The commencement of the wedge should give two parts of blue, one of indigo, one of violet, one of red, and two of yellow, nearly as *Tab.* 3. *i.* or as *Tab.* 4. *d.* The dark blue, indigo, and violet will continue as long as their respective parallels or breadths along the productor: the red should be perfect and will become more dilute and approach crimson, as it gets to the narrow end of the first segment, the yellow and blue will diminish in proportion, or appear more dilute. The beginning of the second segment will have crimson in the place of the red, which will be paler at the end; the yellows and blues diminish of course. The third segment will have a middle crimson or a crimson more dilute, as also the yellow and blue. The fourth segment will have light crimson with light yellows and blues. The fifth segment will have pinks or paler crimsons, yellows, and blues till they all fade into light.

THE UNIVERSAL CHROMATOMER, *Tab. 7. lower fig.*

This is formed of segments of the wedge, parallelized in certain proportions, and which may be called indicators and determinators *. They are brought near to each other to mix and form the binaries and ternaries.

The narrow end of the upper determinator gives the proportions of yellows, reds, and blues, according to its respective width, and so to the middle with some violet. The two next segments give also the same proportions of colour as the upper wedge; but, according to the proportionate distance exemplified in *Tab.* 3. and 4., mix with the next determinators immediately under them forming light to darker greens. The second five segments form chiefly light blues and light to denser crimsons. Between the second and third sets of determinators will be found verdigrease-like greens. The third determinator will have light and dark browns; between it and the fourth will be light and dark grays at the broader end. The fourth and fifth will produce pinks, light brownish orange to nearly orange at the broadest end. As every determinator gives its exact propor-

* Indicators, when they are competent to show the tint or colour indicated by the comparative proportions: thus, as sir Joshua Reynolds says, "Theory is the art of knowing what is truly Nature." Determinators, when with the help of the prism we can determine the proportions.

tion of colours, so they must mix in these proportions, and I know nothing more beautiful than to witness it; yet like many other things, it requires some practice to arrive at tolerable perfection. This scheme is in its nature perfect, and calculation, measure, &c. will prove it; but how far the limited powers of mankind will carry it, remains a desideratum. One man can divide a micrometer into 25 million parts per square inch, in every line of which seems a whole suit of colours; but whether any can carry it much further is not known. The chromatometer is capable of every degree of extension or of the most minute division. I left off in the upper chromatometer nearly in a point; in the lower one at a determined measure about $\frac{1}{32}$d part of an inch.

OF THE MIXING OF MATERIAL COLOURS, OR THE CHROMATIC SCALE.

The mixing of material colours is very simple, if we dwell upon the idea of the three primitives; otherwise the very beginning is absolute confusion, as will be seen in most preceding attempts; it is much easier to comprehend this figure than to mix the chromatic tints, as the primitive colours are distinctly seen passing into each other and forming orange, green, and purple, see 1, 2, 3. The centre of the triangle and circle, *Tab.* 5. and 6. we consider as analogous to light or white, represented as passing or spreading under the triangle, gradually passing to a nearly distinct tint; that is to say, yellow, red, and blue when mixed or in union with certain proportions of light or white, do not give positive ideas of yellow, red and blue, the yellow having a grayer tinge, if I may use the expression, and the red rather a bluish tinge, the blue also losing its beauty with a duller or grayish appearance *. To make short of it, I shall call these the primitive colours diluted, which in the figure are, I presume, yet sufficiently to be understood as far as the circle continues,

* These are analogous to the appearance of whorled mixtures, too often compared to white, whorling being an aërial dilution of colours.

but most so at the extremities where they are strongest; and they are put upon the paper in such a gradation that, however the space is confined and the tints consequently innumerable, they may be identified by the measures from the centre with the compasses; and so nearly do the different copies correspond with one another, that they will pretty well accord with the nicest comparison of which we can be sensible.

The inner triangle commences, as it were, with a tint darker than the circumference of the circle above described, and the next or middle portion shows the yellow, red, and blue still more determined, and the outer triangle, perhaps, most perfect, or what I would wish to consider as the fullest and most determined colours which I have got pretty well represented. These three divisions are distinct, and I call the innermost, light, the next, middle, and the outer, the full tint, which may be compared to the upper wedge, *Tab.* 7. The full red may be found at the beginning of the wedge, the middle red at about the middle of the second line, and the pale red at the end of the third line; when the whole is adjusted, portions of the yellow and blue in the same parts of the wedge will also accord. Thus three degrees of the simple or *primary* tints. These, passing over each other at the angles, form binaries; being at one corner, orange; at another, green; and at the other purple. Thus light yellow and light red form light orange; middle yellow, and middle red, form middle orange; and full yellow, and full red, form full orange; light yellow, and middle red, forming reddish orange, &c.; in all nine distinct tints, and the same with the greens and purples; for a fuller description see the nomenclature to the chromatic scale.

Now these may form ternaries by adding to them the third colours,—to the orange blue, to the green red, and to the purple yellow; thus are formed the different browns or ternaries, which must always consist of the three primaries as the chromatometer shows: these are innumerable of course, as they may be lighter or darker, orange, green, or purple browns, &c.

The lower circle *c. d.* represents two of the three principal browns, beginning at light, viz. yellowish browns, red brown, and bluish or grayish brown, &c.

The three extra lozenged quadrangles are continued from the yellow and red forming orange, and the third tint blue is in the three degrees passed over them.

The first or light blue forming chiefly orange browns; the second or middle forming greener browns; and the third or full blue forming the darker or grayer and bluer browns.

CHROMATIC SCALE.

In order that the tints in the former plate 5 should not be blackened by figures, I have annexed the following one, plate 6 to explain the primaries, binaries, and ternaries, or form a list of tints in as simple an arrangement as possible, selecting the usual terms or commonest nomenclature, that it might be generally understood. I have expressed the yellow by dots, the red by undulating lines, and the blue by straight lines. It may therefore be understood what colours pass into each other to form the binaries and ternaries, with a precision equal to that of a coloured example. These, in proper proportions, may serve to practise on, in some measure like the lines in heraldry, in the place of representing colours, upon many occasions, as in engraving, &c. I now proceed to my nomenclature; and, as much information may be given by letters or figures, at present I shall use small *Italics* for light tints, small Roman characters for middle tints, and ROMAN CAPITALS for the full or perfect tints, as I have before termed them:

y therefore may signify light yellow,
y ———————— middle do.
Y ———————— full do.,

and the same of the red and blue.

BINARIES may therefore be explained by *y*. r., signifying *light yellow* and middle red; and ternaries thus, *y*. r. B., signifying *light yellow*, middle red, and FULL BLUE; which will be easily understood by the chromatic scale and table*. Latin terms are added upon excellent authority, with as much precision as possible. It appears that they have been taken too indefinitely in general, and it is the less to be wondered at, as there is so little agreement among authors with regard to colours every where.

NOMENCLATURE FOR THE CHROMATIC SCALE,

Primaries.

Yellows.

1	Light yellow, Pallide flavus, - - - - - - - - - - - -	*y.*
2	Middle yellow, Flavus, - - - - - - - - - - - - - -	y.
3	Full yellow, Saturate flavus, - - - - - - - - - - - -	Y.

Reds.

4	Light red, Pallide ruber, - - - - - - - - - - - - -	*r.*
5	Middle red, Ruber, - - - - - - - - - - - - - - - -	r.
6	Full red, Saturate ruber, - - - - - - - - - - - - -	R.

Blues.

7	Light blue, Pallide cæruleus, - - - - - - - - - - -	*b.*
8	Middle blue, Cæruleus, - - - - - - - - - - - - - -	b.
9	Full blue, Saturate cæruleus, - - - - - - - - - - -	B.

Binaries.

10	Reddish yellow, Rubescente flavus, - - - - - - -	Y. *r.*
11	Yellowish orange, Flavescente aurantiacus, - - - -	y. *r.*
12	Full do. Saturate flavescente aurantiacus, - - - -	Y. r.
13	Light orange, Pallide aurantiacus, - - - - - - - -	*y.* r.
14	Middle orange, Aurantiacus, - - - - - - - - - -	y. r.
15	Full orange, Saturate aurantiacus, - - - - - - - -	Y. R.
16	Reddish orange, Rubescente aurantiacus, - - - - - -	*y.* r.

* Should any of these methods of expressing colours be adopted, there will be a standard for any tint, as they may be identified by either mode of expression; and the measure of any one, or all, may be referred to, whether primary, binary, or ternary.

17 Full orange, Saturate rubescente aurantiacus, - - - y. R.

18 Yellowish red, Flavescente ruber, - - - - - - - - *y*. R.

19 Bluish red, Cærulescente ruber, - - - - - - - - *b*. R.

20 Reddish purple, Rubescente violaceus, - - - - - - *b*. r.

21 Full do., Saturate rubescente violaceus, - - - b. R.

22 Light purple, Pallide violaceus, - - - - - - - - - *b*. *r*.

23 Middle purple, Violaceus, - - - - - - - - - - b. r.

24 Full purple, Saturate violaceus, - - - - - - - - - B. R.

25 Bluish purple, Cærulescente violaceus, - - - - - - b. *r*.

26 Full do., Saturate cærulescente violaceus, - - - B. r.

27 Reddish blue, Rubescente cæruleus, - - - - - - - B. *r*.

28 Yellowish blue, Flavescente cæruleus, - - - - - - B. *y*.

29 Bluish green, Cærulescente viridis, - - - - - - - b. *y*.

30 Full do., Saturate cærulescente viridis, - - - - B. y.

31 Light green, Pallide viridis, - - - - - - - - - - - *b*. *y*.

32 Middle green, Viridis, - - - - - - - - - - - - b. y.

33 Full green, Saturate viridis, - - - - - - - - - - B. Y.

34 Yellowish green, Flavescente viridis, - - - - - - - *b*. y.

35 Full do., Saturate flavescente viridis, - - - b. Y.

36 Bluish yellow, Cærulescente flavus, - - - - - - - *b*. Y.

Ternaries.

37 Full brownish yellow, Saturate brunnescente flavus, - *b*. *r*. Y.

38 Middle yellowish brown, Flavescente brunneus, - - *b*. *r*. y.

39 Yellow orange brown, Flavo aurantiaco brunneus, - *b*. r. Y.

40 Light brown, Pallide brunneus, - - - - - - - - - *b*. *r*. *y*.

41 Middle orange brown, Aurantiaco brunneus, - - - *b*. r. y.

42 Brownish orange, Brunnescente aurantiacus, - - - *b*. R. Y.

43 Reddish brown, Rubescente brunneus, - - - - - - *b*. r. *y*.

44 Reddish orange brown, Rubescente aurantiaco brunneus, *b*. R. y.

45 Brownish red, Brunnescente ruber, - - - - - *b*. R. *y*.

46 Brownish yellow green, Brunnescente flavo viridis, - Y. *r*. b.

47 Middle greenish gray, Viridescente griseus, - - - y. *r*. b.

48 Full yellowish brown, Saturate flavescente brunneus, Y. r. b.

49 Bluish gray, Cærulescente griseus, - - - - - - - *y. r.* b.
50 Middle brown, Brunneus, - - - - - - - - - - y. r. b.
51 Full orange brown, Saturate aurantiaco brunneus, - Y. R. b.
52 Purplish gray, Violascente griseus, - - - - - - - *y.* r. b.
53 Full reddish brown, Saturate rubescente brunneus, - y. R. b.
54 Brownish purple, Brunnescente violaceus, - - - *y.* R. b.
55 Blackish green, Nigrescente viridis, - - - - - - Y. *r.* B.
56 Brownish blue, Brunnescente cyaneus, - - - - y. *r.* B.
57 Greenish black, Viridescente niger, - - - - - - Y. r. B.
58 Blackish blue, Nigro cyaneus, - - - - - - - - - *y. r.* B.
59 Bluish black *, Cæruleo niger, - - - - - - - - y. r. B.
60 Full brown, Saturate brunneus, - - - - - - - - Y. R. B.
61 Blackish blue purple, Nigro cyaneo violaceus, - - - *y.* r. B.
62 Purplish black, Violascente niger, - - - - - - - y. R. B.
63 Blackish purple, Nigro violaceus, - - - - - - - *y.* R. B.
a Yellowish white, Flavescente albus.
b Reddish white, Rubescente albus.
c Bluish white, Cærulescente albus.
d Brownish white, Brunnescente albus.
e Grayish white, Canescente albus.

I intended to have had the light, middle, and full tints so as to consider the latter or full colour, as giving no other idea than that of a perfect yellow, red, and blue, so that the simple names flavus, ruber, and cæruleus might correspond, which now stand for the middle colours which are neither light nor strong, and must be considered as tints that are exactly betwixt the extremes; yellow, for example, under these circumstances, is neither light nor full, and is not by any means to partake of any tinge of red or blue. Thus light yellow is yellow distinct, mixed with light or white in such a proportion that it has not another tint, as a little more white would somewhat obliterate or disguise it. The middle being a determined yellow, neither light nor strong. The full may be conceived as such an ac-

* True black would be between this and brown, but nearest to bluish black.

cumulation of mere yellow, that to add more would give an idea of another colour bordering on orange. The same of red and blue. Black is as it were a supersaturation of the darkest tints: thus full brown or saturate brunneus with a supersaturate portion of blue will be analogous to black. Grays may be made upon this principle by adding a portion of blue to the light and middle browns.

Having reconciled the primitive of all tints, and colours, on the most permanent basis, it becomes necessary to speak of the material colours, it being one of the first objects of my intention to simplify them.

MATERIAL COLOURS USEFUL TO ARTISTS.

The most perfect are those that have some transparency, as they may be applied with greater variety, and as every object is seen through a transparent medium, which helps to give an effect that the artist is otherwise too often unable to accomplish, and for which much pains is taken by glazing with the help of gum or varnish assisted with asphaltum. I should think that, the fewer the ingredients the more perfectly they may be understood; but, being easily comprehended, perhaps they may be more casually passed over; yet it were better to understand a few things well, than to be confounded with a multitude.

It happens that what are called material colours are not all so permanent as might be desirable, and the artists in oil or water colours, and even in enamel, are often much troubled to accomplish their ends on this account. Mineral colours for enamel are often so tender as easily to be affected by a small difference of heat in fixing, and those for oil or water colours often readily change by exposure to air. Vegetable colours are more used in water or size colourings or paintings, but are only fit to be kept in portfolios or books. Colours from animal substances are least in use; and although Nature allows us to procure colours from either of these three great divisions for our different uses, they may all depend upon nearly the same bases; which however yet remains to be found out. I will now enumerate the most necessary or useful colours in the simple order of Yellow, Red, and Blue, with some hint of their general properties.

White is only considered as a heightener; white lead or carbonate of lead serves in oil generally, and the oil partly preserves it; it soon changes with water. Barytes white is now adapted to use with water colours, and is very good; whitening is used for ordinary purposes.

Whites are naturally opaque, and I think conveniently so to give solidity when occasion requires it: thus, scarce any thing is wanting to a good artist: it is as it were a neutral, as well as black or dark, upon which true colours depend.

PRIMARIES.

Yellows. 1 Gamboge is most perfect yellow, used in water colours.
2 Lake
3 King's, semimetallic, opaque
4 Naples
5 Patent
6 Ochre, earthy with oxide of iron, *British Mineralogy, tab.* 253.

Reds. 1 Carmine, most perfect when good
2 Lake
3 Burnt ochre, called red ochre, not perfect red
4 Venetian red, commonly so called, rather a deep rusty colour.

Blues. 1 Prussian or Berlin blue, most perfect
2 Antwerp blue, greenish blue
3 Indigo, dull, strong
4 Smalt, cobalt, purplish.]

BINARIES.

Yellow and red. Orange orpiment
Chromate of lead
Oxide of lead
Vermilion, scarlet.

Yellow and blue. Verdigrise
Terre vert.
Purple or violet, or red and blue.
Cochineal
Logwood.

TERNARIES.

Yellow, red, and blue.
Terra Siennæ, rather orange brown
Umbers, reddish brown
Terra Sepiæ, cuttle brown, nearly neutral, not inclining either to yellow, red, or blue.
Black.

No. 1 Gamboge, capable of solution in water or oil, from very transparent dilute or light to a somewhat opaque perfect yellow, but, if stronger, inclines to a reddish cast. Most commonly used in water. Liable to fade on exposure to light. Often makes good binaries: with blue, green; with red, orange; or ternaries, with the red and blue, as browns.

2 Yellow lake, used in oil, makes much the same binaries and ternaries as the above.

3 King's yellow, adapted to opaque water colours, but liable to change slightly.

4 Naples yellow, (must not be rubbed with a metal palette knife,) a bright durable yellow sometimes used in oil.

5 Patent yellow, when used in oil, is more durable than in water, in which it is liable to change soon to a dark brown.

6 Yellow ochre, used most commonly in oil, gets more forcible, if I may use the expression, and is afterwards durable; it is rather a brown yellow: see *B. M. tab.* 253, p. 104.

1 Carmine red, or Lake. The latter is rather adulterated carmine, to make it seem cheaper and go further, and to serve in oil. Carmine when properly prepared is perhaps the

most perfect colour; may be used in mixtures with the same facility as gamboge, from thin, nearly transparent, to strong, nearly opaque.

2 Vermilion, sometimes approaches this, but generally borders on orange or scarlet, that is, having a little yellow mixed. So we have but one perfect red. Those called red ochre or Venetian red are comparatively yellow or brown reds; the first is useful in oil, the latter in water or size.

1 Prussian blue may be used in water or oil; it is the most perfect blue we know, but has a purplish tinge in some instances. It is extremely useful in forming greens with gamboge, and purples with reds, and ternaries or browns with both.

2 Indigo blue, chiefly useful for fixing shades that are to be worked over in water colours, is dull.

3 Smalt blue, most permanent, most rich with a red cast, difficult to use.

The best yellows, reds and blues will form good binaries, as mentioned above.

The local binaries, if I may so call such as nature produces chemically, and as it were without apparent mixture, are:

1 Vermilion, sulphuret of quicksilver, used in oil or water, is liable to change on exposure to air; oil or varnish defends it, which gum Arabic does somewhat as a water colour.

2 Orpiment, sometimes yellow, liable to change.

3 Orange or red lead, liable to change.

4 Chromate of lead, changes green with heat, has not been much used in England.

1 Verdigrise, used in water or oil, very bright yellow or blue, may have gamboge mixed with it, changes most in oil.

2 Terre-verte, used in oil, not bright but durable, probably used by the ancients of the Venetian school: see *Brit. Min. tab.* 272.

The three best primitives will make any ternaries, if well managed, and even produce the blackest effect possible.

Terra Siennæ, umber and Coulognes earth are cheaper.

—— Sepiæ, the cuttle fish brown, commonly so called, is a sort of neutral, as all browns are, being chiefly used for shades, but should vary with the subject to be represented.

Those that may be used in oil may generally be used for printing in colours, &c.

As perfect black is rather a desideratum in printing, I might advise transparent red or blue, which may be added to lamp or Franckfort black, to take from their dull opacity,—the red to the lamp black, commonly called blue black ; and the blue to the other when too brown. A discreet printer will know by a trifling hint what to do.

Painters of experience do not generally want the finest colours for their works, as they can give a natural and fine effect by properly contrasting them in chiar' oscuro, &c.: and it is not the best paint or best tools that make the best artists: yet some hint may be of use to judicious hands. No merit is of consequence without competent judges.

I have used ordinary colours all through the present work, because it will show the more general extent of common colours. The best preparations might have seemed to have given a fuller effect, but would perhaps mislead, as too much might have been attributed to their gaiety, and not to their order: my list is therefore only as follows,

Gamboge
Carmine
Prussian blue:

a few others as occasional auxiliaries may now and then be useful for cheapness in back grounds, drapery, &c.

Among minerals, the three substances which approach nearest to the colours of the three primitives are:

Yellow, orpiment, or sulphuret of arsenic.

Red, realgar, or red sulphuret of arsenic.

Blue, lapis lazuli.

Among vegetables, the petals of ranunculus, and the lemon peeling are yellow, as well as many other plants and parts of plants. The fruit of Ribes rubrum, or red currant, and the fructification of Lichen cocciferus are red. The flowers of Veronica saxatilis, *E. B. tab.* 1027, and alpina, *E. B. tab.* 484, are blue; and those of V. spicata, *E. B. tab.* 2, are full blue.

Binaries and Ternaries are more universal.

Colours are identically the same on any substance however reflected, whether mineral, as from earthy or metallic ones; vegetable, as from flowers or fruit; or animal, as from hair, feathers, &c. The same colours may be reflected very dully and afterwards be mixed by shade till lost in darkness, as may be readily understood if we colour different substances with the same yellow, red, or blue, such as paper, silk, velvet, or silver.

I once thought of making more references to the three primitive colours in minerals, vegetables, and animals: however, as minerals are chiefly used, so they come of course in their places as material colours. Vegetables in Great Britain have good yellows, as most Ranunculuses; perfect blues are more scarce, and perfect reds also. I cannot find that we can refer to any British insect for yellow, red, or blue. The Rev. W. Kirby, author of the Monographia Apum Angliæ, was so good as to point out some parts of insects, including some foreign ones, that would identify these colours very well, when the specimens are perfect; but perhaps it might be aggravating to make these references, as something might be wrong. Birds and quadrupeds have the local colours in parts occasionally very brilliant. The scarlet Ibis is universally allowed to be so; and D. Turner, Esq. in his Fuci, considers red as between crimson and scarlet; which seems to me to be perfectly correct. I need here say no more, but refer to the Chromatometer as the instrument or more perfect instructor when duly attended to; and I have no doubt that by such attention reasonable ideas will become more general, and lead to improvement in the hands of some person who has a happy independent leisure, and abilities not only to add calculations for the more exact proportions and distances, but to show what is the utmost extent of its utility.

The Rev. W. Kirby informs me that Lamarck is said by Latreille to have given a chromatic scale of colours; and from a sketch which he was so kind as to give me, just as I was about to send this to the press, I find it was very conclusive as far as it went, and is truly ingenious. He observes that the colours of the rainbow or prism are not in the natural order, but exhibit two reversed branches of that order joined together, white and black being suppressed, which he affirms are the extremities of the natural series of colours: by this reversion the yellow is laid next to the blue, and from the mixture of yellow and blue rays results green, observable in the rainbow. Yellow, red, and blue, he considers as three principal points of coloration; for the type of these colours he takes the middle part of the yellow, red, and blue bands of the rainbow. He observes that although it is very easy to determine the colour of the middle part of the red band, because that band has its full width, yet it is more difficult to determine that of the blue and yellow bands, because these bands have half their width taken up to form the green band. He then forms by proportion binaries, and mixtures, of which he gives an instructive table, and an arrangement which clearly points out the difficulties that attend accuracy in this subject. It shows also that it is natural to apply to the prismatic colours for an original source, and by that application how various the ideas and modes of improvement have been, while all have had a similar confidence of being most perfect.

Perhaps there may have been ages of perfection in this subject, which are lost, like other things that do not depend upon durable materials; as the statues of Praxiteles, which being handed down to us give evident proofs of great perfection in those days. Indeed I can scarce help thinking that I have seen something in antiquity that belongs to a compounded wedge, such as I have constructed for a measurer of colours: if so, it may help to unravel a mystery; and I hope antiquaries will not forget to inquire into the subject, should it ever come into their hands.

According to Dr. Young, "Dr. Wollaston has determined the division of the coloured image or spectrum in a more accurate manner than had been done before: by looking through a prism at a narrow line of light, he produces a more effectual separation of the colours than can be obtained by the common method of throwing the sun's image on a wall. The spectrum formed in this manner consists of four colours only, viz. red, green, blue, and violet."

"The colours differ scarcely in their quality within their respective limits, but they differ in brightness; the greatest intensity of light being in that part of the green that is nearest the red; a narrow line of yellow is generally visible at the limits of the red and green, but its breadth scarcely exceeds that of the aperture by which the light is admitted; and Dr. Wollaston attributes it to the mixture of the red with the green light, which is found to be the same, whatever refracting powers may have been used for its formation."

"If the breadth of the aperture viewed through a prism is increased, the space occupied by each variety of light in the spectrum is augmented in the same proportion, and each portion encroaches on the neighbouring colours and is mixed with them; so that the red is succeeded by orange, yellow, yellowish green, and on the other side by violet, and it is in this state the prismatic spectrum is commonly exhibited." Thus there are five colours to this specimen of Dr. Young's common prismatic spectrum, four positive ones to Dr. Wollaston's, and five doubtful; but seven to Sir Isaac Newton's.

The doctor proceeds to observe, that "when a beam of light is so much enlarged as to exceed the angular magnitude of the spectrum, it retains its whiteness in the centre, and is terminated by two different series of different colours at the different ends. These series are still divided by well marked lines; on the one hand, the red remains unmixed; the space belonging to the green and blue becomes a greenish yellow nearly uniform throughout, and here the appearance of the colour ends, the place of the violet being scarcely distinguishable from the neighbouring white light." If Dr. Young had had a perfect line of light, viz. with an equal appearance of centre and sides altogether resembling white, the three primitive tints would probably have presented themselves to him as in my *Tab.* 2, *fig.* 3. Therefore he was near seeing what might, in such hands, have proved useful.

It is further observed that "the effect of white light on the sense of sight might be imitated by a mixture of colours taken from different parts of the spectrum, notwithstanding the omission of some of the rays naturally belonging to white light. Thus, if we intercept one half of each of the principal portions into which the spectrum is divided, the remaining halves, when mixed together, will still preserve the appearance of whiteness; so that it is probable that the different parts of these portions of the spectrum which appear of one colour, have precisely the same effect in the eye. It is certain that the perfect sensations of yellow and blue are produced respectively, by mixture of red and green and of green and violet light, and there is reason to suspect that those sensations are always compounded of the separate sensations combined; at least this supposition simplifies the theory of colours. It may therefore be adopted with advantage until it be found inconsistent with any of the phænomena; and we may consider the white light as composed of a mixture of red, green, and violet only, in the proportions of two parts of red, four of green, and one of violet, with respect to the quantity or intensity of the sensations produced." Again: "From these three simple sensations with their combinations we obtain seven primitive distinctions of colours *; but the different proportions, in which they may be combined, afford a variety of tints beyond all calculation. The three simple sensations being red, green, and violet, the three binary combinations are yellow, consisting of red and green; crimson, of red and violet; and blue, of green and violet; and the seventh in order is white light composed of all three united; but the blue

* Thus we have seven colours differing from Sir Isaac Newton's.

thus produced by combining the whole of the green and violet rays is not the blue of the spectrum: four parts of green and one of violet make a blue, differing very little from green; while the blue of the spectrum appears to contain as much violet as green, and it is for this reason that red and blue usually make a purple, deriving its hue from the predominance of the violet."

The doctor says, "It would be possible to exhibit at once to the eye the combinations of any three colours in all imaginable varieties; two might be laid down on a revolving surface, in form of triangles placed in opposite directions, and the third on projections perpendicular to the surface, which, while the eye remains at rest in any one point, obliquely situated, would exhibit more or less of their painted sides, as they passed their different angular positions; and the only further alteration that could be produced in any of the tints, would be derived from the different degrees of light only. The same effect may also be exhibited by mixing colours in different proportions by means of the pencil, beginning from the equidistant points or centres."

This, I think, seems a conclusive argument of the utility of the knowledge of the three primitives, viz. yellow, red, and blue; for it is impossible for the compound sensations, as I would call the green and violet, with or without the red, to produce yellow in any part of the triangle; and this is confessed in the following explanation of Dr. Young's *fig.* 427: "A triangular figure exhibiting in theory all possible shades of colours; the red, green, and white are single in their respective angles, and are generally shaded off towards the opposite sides; a little *yellow* and *blue* only are added in their places in order to supply the want of brilliancy in the colours which ought to compose them. The centre is gray, and the light of any two colours which are found at equal distances on opposite sides of it, would always very nearly make up together white light, as yellow and violet, greenish blue and red, or blue and orange."

This triangle of Dr. Young's will only make a variety of light or dark browns, which any three colours, simple or mixed, would, if passed from the three corners over each other to the opposite sides, as he places them. If this would make "all possible colours," there would be no occasion for *yellow* and *blue*, which were wanted, and which he has been obliged to put in: here it is plain that simple yellow and blue must answer for themselves, even under the dulling influence of the general mixture *.

There are many phænomena attending the iris-like colours, which will now easily be reduced to some philosophical order for description, and prevent that vague and confused uncertainty that prevails in many works, and which I did not dare to quote, however curious, as in some parts they might be above my abilities to comprehend.

Before printing this little essay, I thought it proper to look at one or two more works, perhaps to supersede my taking any more trouble about the matter; but finding nearly the same difficulties arise, I ventured to proceed. Indeed I was pleased that Jameson, in the eight fundamental colours of Werner, admits, if I take the meaning right, of Yellow, which he compares to ripe lemons, Blue, which he calls Berlin blue, commonly called Prussian blue, and Red, which is carmine.

These agree with my ideas, and are exact, as I have shown; and it may be universally known that these three are not naturally compounded of others, or made of mixtures, but are the bases of all possible tints. Their not being used as such makes most of his compounds unnatural and absurd, as a few examples will easily show. The common appellations may be good, such as " snow white;" but simply " white" might have been better, as it could properly have no other meaning.

Ash gray is very indeterminate.

Velvet black is misleading. Black must be the same on any sub-

* It will be found that we can represent the primaries, yellow, red, and blue, and their binaries, orange, greens, and violet, in every possible variety, passing among each other in a sketch without motions; but we cannot represent all the ternaries, or browns, grays and darks, without the motion of one of the primitives. I have got three triangles and quadrangles, prepared simply to show all mixtures, which will prove this.

stance. Velvet has various appearances, from its construction, distinct from colour.

Emerald green is good; but green is very properly a compound, and the emerald may be more or less perfect, thick or thin, &c.

"Reddish white" might do very well without the explanation, which makes it quite absurd: it is "snow white with a little crimson and ash gray." If any philosopher or other person were to endeavour to compound this confounded mess, they will see no natural means of doing it. First, they must have, I suppose, a perfect white, for snow white; then some white mixed with black for ash gray; and lastly, some "carmine red with a considerable proportion of blue, for crimson. If I can guess at the sequel, it will prove a very muddy affair. "White with a little red" would have done better, and would have been both natural and simple.

This I think a sufficient example. It might be deemed invidious to point out more, and the whole speaks for itself. I have done thus much as a duty; others may take the task of judging and criticizing. What I have done will show them that they may produce any variety of tints, even beyond all calculation, if the three simple primitives, as I call them, are used. I am only aiming at simplicity, the foundation of every thing natural.

When I wished to have concluded, which I should have done long since on the original plan, I happened occasionally to meet with something which many persons might think should not be passed over. However, as I might seem negligent if I did not make some applicable observations, I say a few words on the Decomposition of Light, by C. A. Prieur*.

He observes that "the disk of the moon, when far from the horizon, with a single prism displays upon her lengthened image several circles, which indicate separations of colours perfectly unblended." I take the liberty of observing, that the more the image is lengthened,

* Annales de Chimie, tom. lix. p. 227. Phil. Mag. vol. p. 162.

the more the colours are blended: they, however, are never *perfectly unblended*, if I understand the term right.

"Examine also with the prism the coloured fringes of a white rectangular body, a little large, and well illuminated, you will remark on one side a red stripe, falling into the yellow abruptly, which, in its turn, loses itself in the white; and on the other hand some blue, distinctly enough between the white and a violet stripe *; from this it would follow that there are only four sorts of colours."

"Again, if we look at a white and narrow body, placed upon a black ground, such as a strip of paper, a thread of silk, or a metallic needle, there will only appear, for one of these objects, if we are properly placed, three colours, red, green and violet, and scarcely can we perceive, either on the one or the other, any softening of the shades." See my *Tab*. 4. These answer in a great measure to a narrow line of light of Dr. Wollaston, which had blue and a little yellow. See *Tab*. 4. *d*. betwixt 3 and 4.

Thus much resembles my *Tab*. 2. *fig*. 3. made narrower, and the violet is more or less perceptible, as it is more or less relieved by a strong light or a dark back ground, especially if widened by the prism .And, upon examination, it will be found to be a mixture of binary tints, and accords well with *Tab*. 4. *d*. The lower part, if at all relieved or shining, will, according to precise laws, show brighter tints; and I have further to observe that this is a mixture of the red, from the nature of the black ground above, with the blue and yellow of the lower black back ground: thus the red is purplish, and the yellow below the red, mixing with the other portion of the blue, forms the green &c. It is not a little curious that C. A. Prieur, having so nearly hit upon the true mixture, should have let it pass. The concordance of my descriptions with his would almost look like a plagiarism, as well with regard to him as with some parts of other de-

* The blue side of the white rectangular body was relieved by some darkness, else no distinct violet stripe. How near to the true order of colours!

scriptions; which is the less a wonder, as everyone endeavouring at the same effect hits on the same causes: but a trifling mistake in conjecture, however, keeps us in that darkness which time alone disperses to show true light and colours,

C. A. Prieur says, "I remarked that, under certain circumstances, the colours exhibited by refraction were almost wholly these three, red, green, and violet; that sometimes yellow appeared to arise from a mixture of red and green; and blue from a mixture of green and violet." This is, in my opinion, really unmixing what were previously mixed; or, properly, substituting a broader light, naturally or artificially, instead of a narrow one: see it partly expressed in *tab. 4. c. d.*

He in another place observes, "How is it that the rays, when taken in pairs from the extremities of every diameter of the dial, that is, from any two opposite points, shall always form the same white? A certain red with a green gives white; and an orange with a blue, the same; and a violet with a yellow, also." It will be found that it is easy to make either or all of them produce white, if it is proper to call it white, which will depend much upon the velocity, or something else; and in material colours they may be more simply termed, and all formed of yellow, red, and blue.

First, Red with green, which is formed of yellow and blue, give white.

Second, Orange, which is formed of red and yellow, and blue, which mixing with the yellow of the orange make a green like the first, so that orange and blue are tantamount to red and green.

Third, A violet with a yellow. Red and blue form violet, the blue of which mixed with the yellow are green; and therefore each being in the same proportion, when mixed, form the same colour. This is so distinct and simple, that it is amazing that there should appear any difficulty to so discerning a gentleman.

I must further observe that each mixture would be a light or darker grayish, brownish or blackish white, depending upon the most prominent colour; but if at regular distances, which is probably meant, it is gray or darkish white.

"I had therefore," he observes, "a problem to solve, the complicated data of which, at first, seemed not to promise a simple solution; yet, after various attempts, I obtained my object, as will be seen. First, I considered that both the nature and quantity of red, green and violent rays, which I suppose to be the sole element of light, are absolutely unknown; but I could likewise conceive them transformed into coloured matters of such intensity or condensation, that the mixture of an equal quantity of each should produce exactly white." I will take the liberty to say that it will be whitest when most spread as common light, and darkest when most condensed: thus they are naturally lost, either way, to our senses, and my figures will show what is meant.

In another place it is observed, that "a pencil of very decided blue, being well formed, on white cloth, a green phial was placed before the hole, when the light of the spot was immediately much weakened, and its colour changed to green." Certainly a very natural result, as green passed over blue, or mixed with it, makes it yellowish or bluish green, according to the quantity of either yellow or blue in the combination, as in material colours: see the triangle, &c. The yellow would be green with a blue phial, and orange with a red one, and blue and red would become violet or purple.

C. A. PRIEUR'S RECAPITULATION.

"Thus our system of colours appears to me reduced to these few data: three sorts of luminous rays of a particular unknown nature; red, green, and violet. Combined by two's, the red and green produce yellow; the green and violet produce blue; the violet and red, purple; and the three together produce white.

"The first and second propositions seem most contradictory, and by no means to agree with the mixing of material colours. We however find, that it is agreeable to the tenets of other philosophers, and of such authority that only what is truly Nature can prevail."

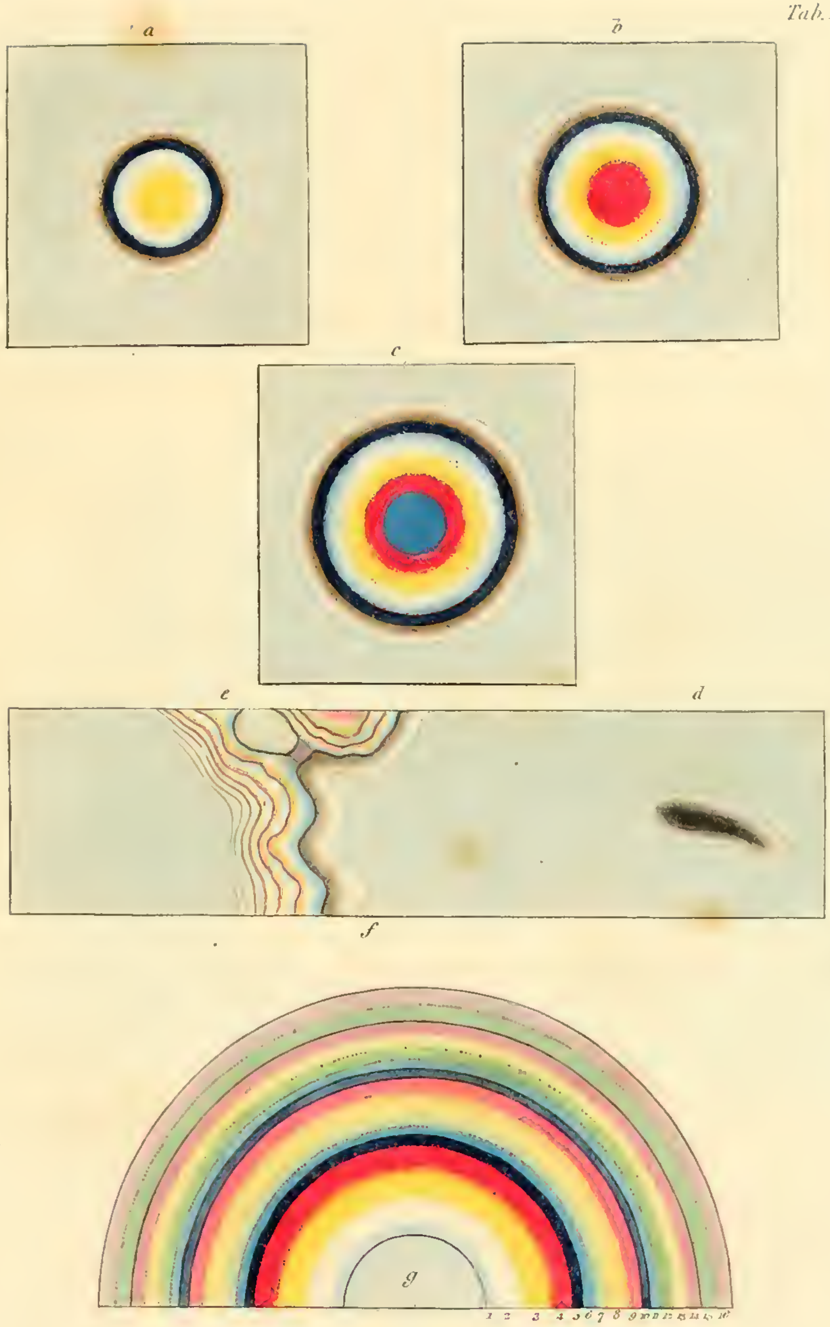
With regard to Mons. Rochon's experiments on the fixed stars, it will be found by the chromatometer, &c., that a proportional smallness and distance may readily be calculated; and it is dependent on these, whether they have white in the centre like the figure of the sun, or are like the star Sirius as it were composed of the three colours, viz., red, green, and violet, with a feeble shade of yellow or not, exactly like Dr. Wollaston's small ray of light, so that its measure when observed by Mons. Rochon was equal, or nearly so, to the diameter of that ray in the star Sirius, and that were he nearer the star, or the star larger, the tints would be proportionally different. Thus Sirius is comparatively as a thread or narrow ray of light, the planets are in their proportions and distances broader, and the sun broadest, (to our Earth) from whose glorious light are derived the three perfect primitive prismatic colours, naturally the parents of all others by mixing and forming binaries, and ternaries, in due order, till lost in night or darkness, when with a new returning morn it again renovates the system.

I need say nothing on the ingenious Dr. Herschel's paper in the Philosophical Transactions, as he knows how to appreciate truth while he is searching for her, and is so nearly on the brink of discovery.

THE END.

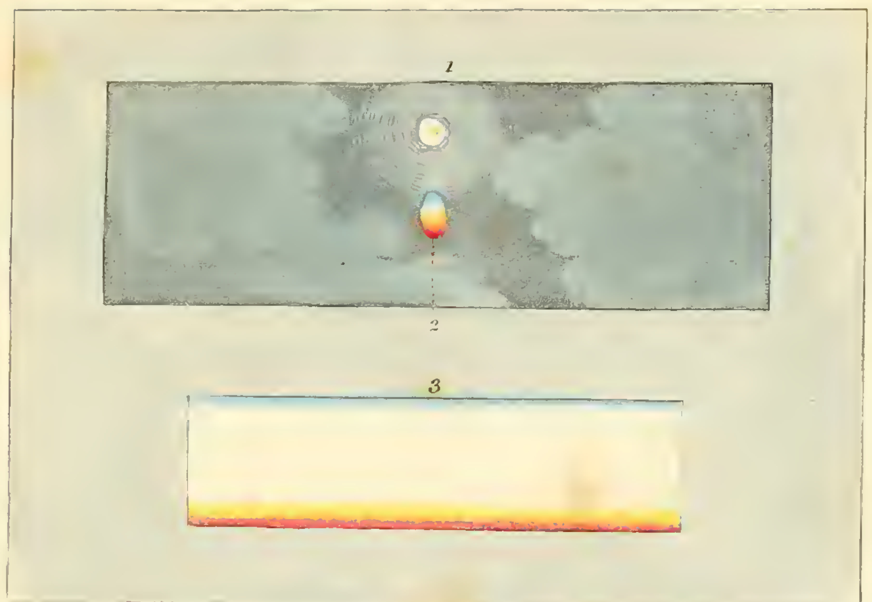
PRINTED BY RICHARD TAYLOR AND CO.
SHOE LANE, LONDON.

Tab. 1.



Oct.1.1807 Publish'd by Ja.s Sowerby, London

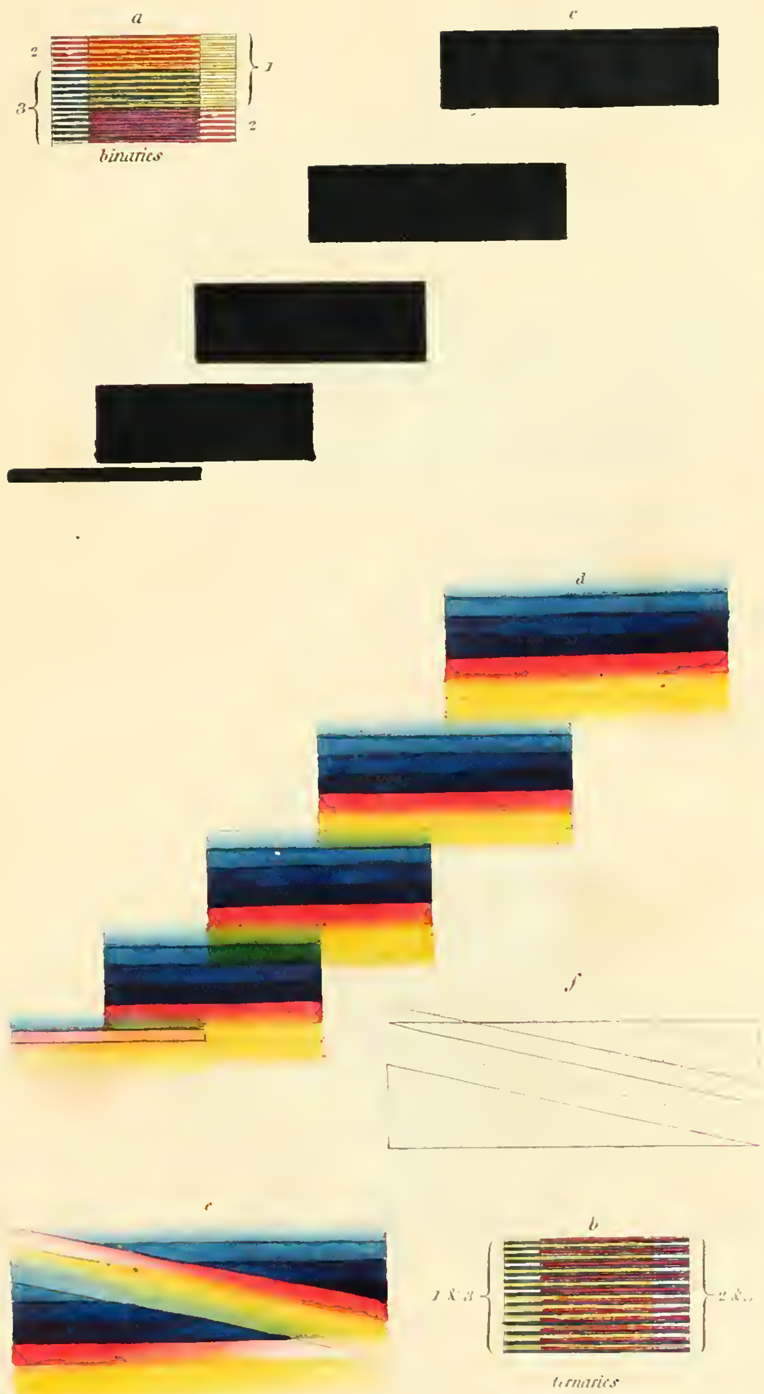
Tab. 2.



Nov 1, 1807. Publish'd by Jas. Sowerby, London.

Nov. 1.1807. Publish'd by Jas. Sowerby London.

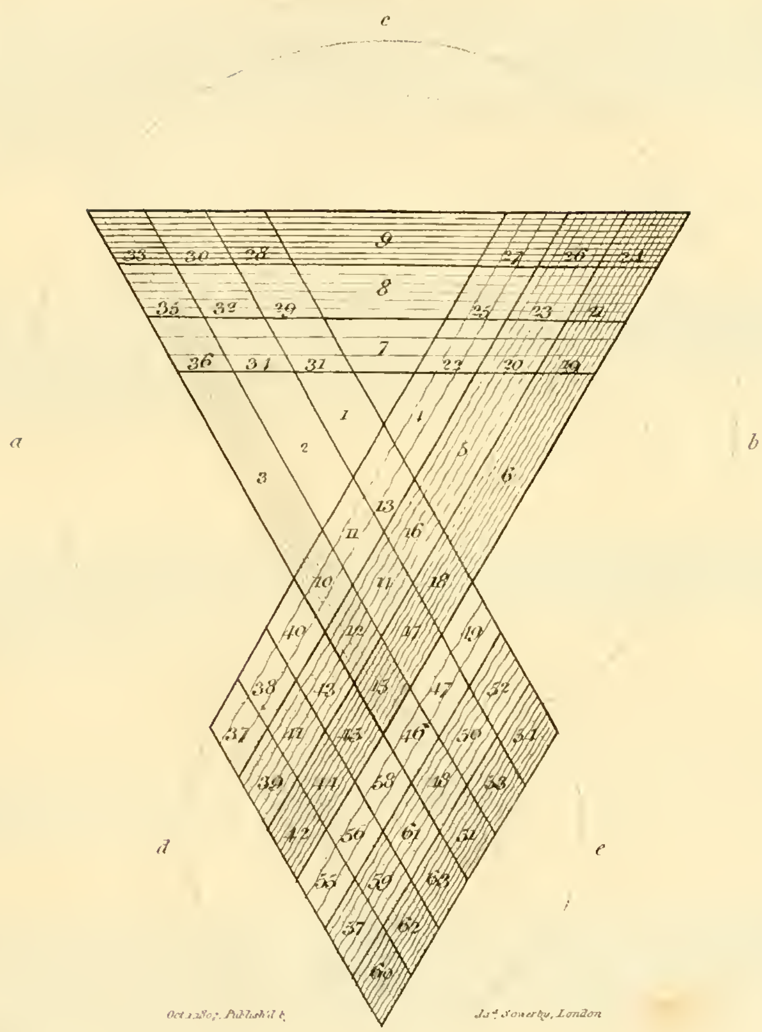
Tab. 1.



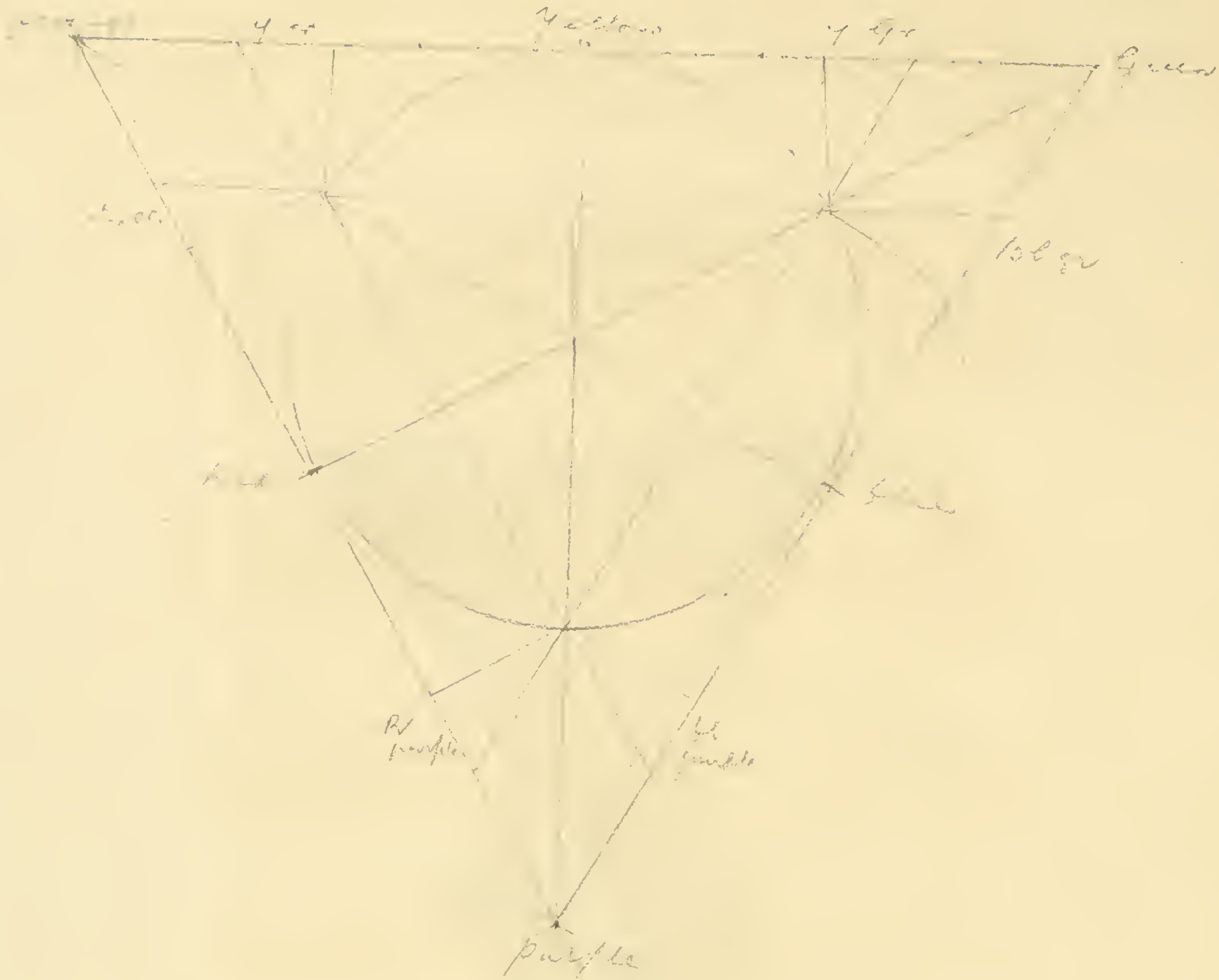
Tab. 5

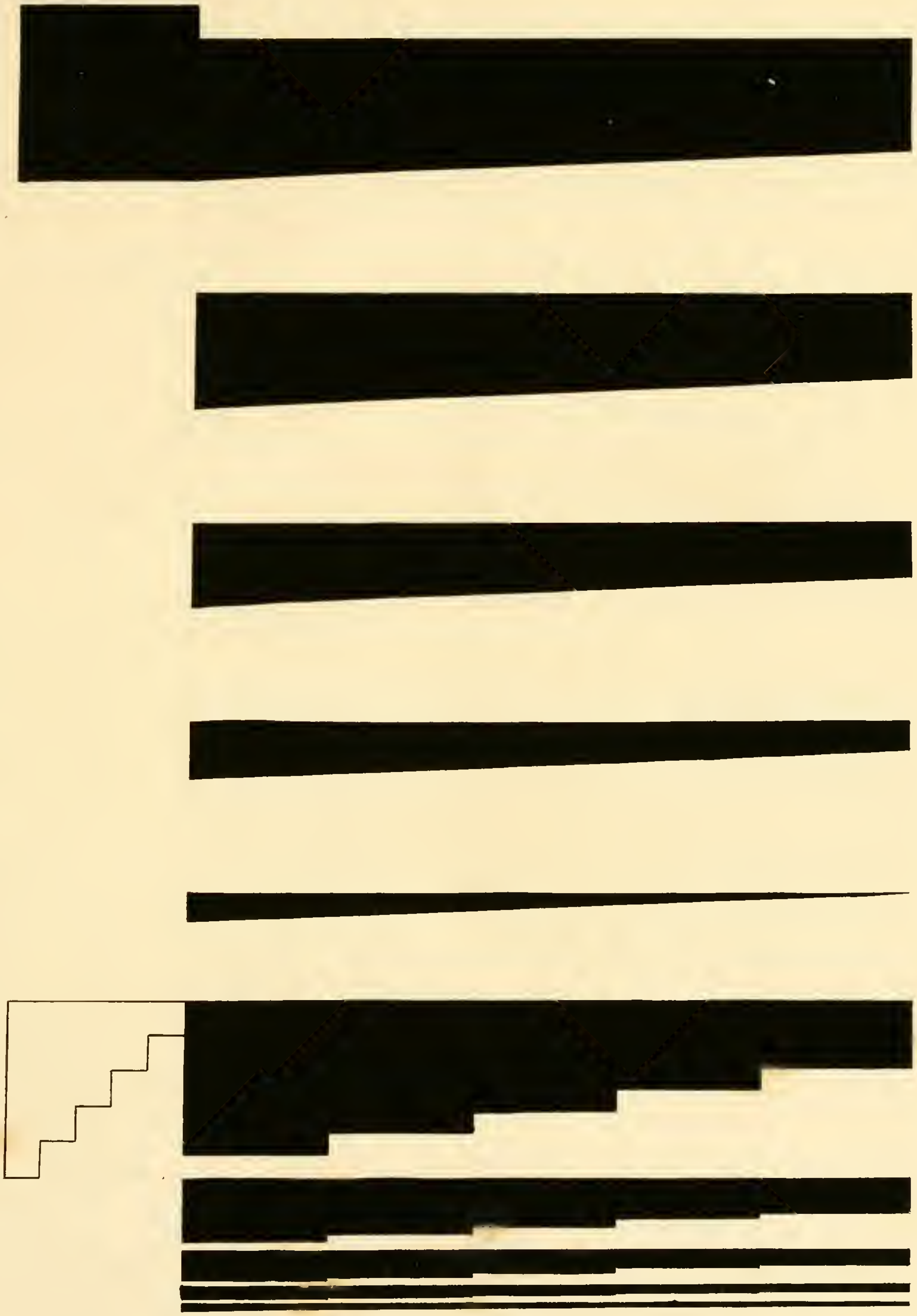
Oct 1 1807 Published by Ja.s Sowerby London.

Chromatic Scale.



Oct. 1 1809. Publish'd by Jas. Sowerby, London


Yellow
Green
Red
Purple



Jan. 1. 1809 Publish'd by Jas. Sowerby London

4. EXOTIC BOTANY, or Coloured Figures of new, beautiful and rare Exotic Plants. No. 1 to 24; 4to, at 5*s.* per Number. 8vo, at 2*s.* 6*d.* each Number.

5. CRYSTALLOGRAPHY; Parts I and II, with Models, 10*s.* 6*d.* each; without Models, 1*s.* each—Intended to explain the Nature of the Crystallization of different Mineral Substances. The First Part on Coals, the Second on Diamond.

6. ENGLISH FUNGI, or Coloured Figures of English Fungi or Mushrooms. By James Sowerby, F.L.S. &c. In 28 Numbers, 10*l.* 6*s.* 6*d.* No. 28 being the First of the Supplement, of which the Second is in the Press, and will be published July 1, 1809.

7. A New Edition of A BOTANICAL DRAWING-BOOK; containing Ten Plates, with Instructions from the simplest Beginning to the highest Finishing; with a concise Description of Transparent and Opaque or Body Colours, &c. Price 10*s.* 6*d.*

8. THREE TRIANGLES of YELLOW, RED, and BLUE, each softened from Light to Full *Yellow*, *Red*, and *Blue*, being the proper Primitives, may be passed over each other to show the Binaries and Ternaries very distinctly: thus showing all possible Mixtures from Light to Dark. 3*s.* the Set.

The same in Squares at the same Price, or both Sets, 5*s.*—See Note, page 46. Plate 7, or Chromatometer, may be had separate, to be used as described, at 2*s.* 6*d.*

As some may desire to attend Mr. S.'s Lecture on this subject on the enlarged scale, by which it may be understood more easily, he intends to keep the Apparatus some time longer; and those desirous, on sending their address, will be informed of the earliest Lecture. Private families, or a few friends, may be accommodated at their own time, at five guineas the party, not exceeding 12 persons, by giving due notice.

*** Mr. SOWERBY has, in the above Works, endeavoured at filling up some of the desiderata of British information with the best intent. Their utility is sufficiently evinced by the publicity they have obtained without the usual aid of continual advertisement.

PRINTED BY RICHARD TAYLOR AND CO.
SHOE LANE, LONDON.

113416

Sowerby

[4], 51, [1] pp, with 7 p.
C&P [illegible]
as per MU